juice obtained with an ordinary mill varies from 60 to 65 per cent. One of the most useful devices for improving the machinery is the substitution of an hydraulic attachment, which can be applied to the headstocks of any of the rollers, in place of the rigid and im­movable screws and wedges of the ordinary mill. This secures a uniform pressure with the most irregular feed and much greater pressure than is possible with rigid rollers, resulting in a greatly increased yield of juice (67 to 70 per cent.) and a megass or refuse proportionately drier and therefore more available for fuel for steam­raising. The juice from the mill is led into a trough, whence it is carried by pipes to the clarifiers. But even the most perfect system of mechanical pressure leaves a large percentage of sugar in the refuse cane, and to remedy this the diffusion method (see below), which has been attended with remarkable success in the beet in­dustry, has been also applied to the extraction of cane j.uice. At Aska (Madras) in India it has been found possible by that process to obtain as much as 87⅜ of the 90 per cent. of juice present in canes. Considerable difficulty was at first found in slicing the silicious stalks for diffusion ; but this process seems to promise a much more exhaustive extraction of the juice than can be secured by mechanical means. The juice is a turbid frothy liquid of a yellowish green colour, with a specific gravity of from 1·070 to about 1·1100. The variety of cane cultivated, its age, and especially the nature of the season in which it has grown as regards rain, all have an important influence on the yield of sugar. The expressed juice contains from 15 to 18 per cent. of solids, showing on a good average—sugar, 14·55 per cent.; glucose, 1·65 ; non-saccharine solids, ·917 ; ash, ·283. The juice got from sugar-cane is much richer in sugar and less contaminated with non-saccharine solids than that yielded by beet ; and its pleasant taste and aromatic odour contrast markedly with the acrid taste and unpleasant smell of beet juice.

*Purification of the Juice.—*In the hot climates where sugar-canes grow a process of fermentation is almost immediately set up in the impure juices from the canes, causing the formation of invert sugar and later products of fermentation, and thereby a serious loss of sugar. It is therefore essential that with the least possible delay the manufacturing processes should be proceeded with. The juice is first filtered through a set of sieves to remove the mechanical impurities it carries from the mill. Then it is run into the clarifiers, a series of iron vessels capable of holding six or eight hun<lred gallons of juice, and in these it is heated up to about 130° Fahr., and milk of lime is added in quantity sufficient to neutralize the acid constituents it contains. The heat is then raised to just under the boiling-point, when gradually a thick scum rises and forms on the surface, and when the defecation thereby effected is complete the clear liquid below is drawn off. Various other sub­stances besides lime are employed for the defecation of juice, one of which, the bisulphite of lime in the so-called Icery process, has attained considerable favour. The bisulphite is added in excess ; the acids of the juice decompose a certain proportion of it, liberat­ing sulphurous acid, which by its influence promotes the coagula­tion of the albuminous principles and at the same time promotes the bleaching of the liquid. In another process the green juice is first treated with sulphurous acid, which (with the natural acid constituents) is subsequently neutralized by lime. Recently also phosphoric acid has come into favour as a defecating agent.

*Boiling Down.—*From the clarifier the juice passes on to the battery, a range of three to five pans or “coppers,” heated by direct fire, in which it is concentrated down to the crystallizing point. The juice, gradually increasing in density, is passed from the one into the other till it reaches the last of the series, the *striking teach,* in which it is concentrated to the granulating point. The skimmings from these pans are collected and used for making rum. From the striking teach the concentrated juice is removed to shallow coolers, in which the crystals form. A few days later it is transferred to hogsheads in the curing-house, and the molasses is drained away from the crystallized raw sugar into tanks. The sugar so obtained is the *muscovado* of the sugar-refiners, and both that and the molasses form their principal raw materials. Clayed sugar consists of raw sugar from which a portion of the adherent molasses has been dissolved by the action of moisture percolating through it from moist clay laid over its surface. Labour difficulties and scarcity of water operate against the general introduction of improved systems of working cane-juice, but in many plantations central usines or sugar-factories have been established with great success. In these the canes of many growers are worked up with the aid of the *triple effect apparatus,* the vacuum pan, and the centrifugal separator employed by beet manufacturers. Wetzel’s pan, Fryer’s concreter, and similar devices for the efficient evapora­tion of juice by exposing it to the action of heat in thin films over an extended surface are also in use.

Beet Sugar Manufacture.—The sugar beet is a cultivated variety of *Beta maritima* (natural order *Chenopodiaceæ),* other varieties of which, under the name of mangold or mangel wurzel, are grown as feeding-roots for cattle. The plants are cultivated like turnips, and the roots attain their maturity in about five months

after sowing, being gathered during September and October. The efforts of growers have been largely directed to the development of roots yielding juice rich in sugar ; and especially in Germany these efforts have been stimulated by the circumstance that excise duty on inland sugar is there calculated on the roots. The duty is based on the assumption that from 121/2 parts of beet 1 part of grain sugar is obtained ; but in actual practice 1 part of raw sugar is now yielded by 9·27 parts of root. Moreover, when the sugar is exported a drawback is paid for that on which no duty was actually levied, and hence indirectly comes the so-called bounty on German sugar. In 1836 for 1 part of sugar 18 parts of beet were used, in 1850 13·8 parts, in 1860 12·7 parts, and now (1887) about 9·25 parts only are required. In France till recently the inland duty was calculated on the raw sugar ; hence the French grower devoted himself to the production of roots of a large size yielding great weight per acre, and had no motive to aim at rich juice and econo­mical production. Many processes, therefore, have come into use in German factories which are not available under the French methods of working. But since 1884 the French manufacturers have had the power to elect whether duty shall be levied on the roots they use or on the raw sugar they make, and a large propor­tion have already chosen the former. The nature of the seasons exercises much influence on the composition of sugar beet, especially on its richness in sugar, which may range from 10 to 20 per cent. The following represents the limits of average composition :—

Water 84·5 to 79·0

Sugar and other soluble bodies 11∙5 to 17·0

Cellulose and other solids 4·0 4·0

The non-saccharine solids in the juice are very complex, embrac­ing albumen, amido-acids, and other nitrogenous bodies, beetroot gum, soluble pectose compounds, fat, colouring matter, with the phosphates, sulphates, oxalates, and citrates of potash, soda, lime, and iron, and silica. The relation and relative proportion of these to the sugar present are of the utmost importance.

Two distinct ways of obtaining the juice from beet are now principally employed,—pressure and diffusion. The mechanical methods of pressure are principally used in France ; the process of diffusion is all but universal in Germany. Formerly a modified diffusion process—maceration—was in use; but it has now been generally abandoned, as has also a means of separating the juice by centrifugal action. For the mechanical processes the roots have first to be reduced to a condition of fine pulp. For this purpose the roots, thoroughly trimmed and washed, are fed into a pulping machine, in which a large drum or cylinder, armed with close-set rows of saw-toothed blades, is revolved with great rapidity, so that the fleshy roots on coming against them are rasped down to a fine uniform pulp. The operation is assisted by pouring small quanti­ties of water or of watery juice on the revolving drum, which thins the pulp somewhat, and aids the free flow of the juice in the sub­sequent operation. The expression of the juice is effected either by the hydraulic press or by continuous roller presses. From the hydraulic press the juice flows freely at first ; but in order to obtain the largest possible yield it is necessary to moisten the first press- cake and submit it to a second pressure, whereby a thin watery juice is expressed. After having been pressed twice, the cake that is left should amount to not more than 17 per cent. of the original roots; hence, allowing 4 per cent. for ligneous tissue, &c., only about 13 per cent. of water, sugar, and soluble salts, &c., remain in the refuse. For the system of continuous pressure presses ana­logous to the mills employed for cane-crushing are used. Many modifications of the roller press have been introduced, and, although the best express from 3 to 5 per cent. less juice than the hydraulic press, they have several advantages under the system formerly common in France, which bound the maker to return press-cake containing a certain proportion of sugar for use as a feeding-stuff’ on the farm. In certain forms of press the lower rollers are per­forated to allow the escape of the expressed juice ; in some the rollers are covered with india-rubber, so that they give an elastic squeeze on an extended surface ; and in others the pulp is carried in an endless cloth through a series of rollers, being all the while subjected to gradually increasing pressure.

The diffusion process for obtaining beet juice depends on the action of dialysis, in which two liquids of different degrees of con­centration separated by a membrane tend to transfuse through the membrane till equilibrium of solution is attained. In the beet the cell-walls are membranes enclosing a solution of sugar. Supposing these cells to be brought into contact with pure water, then by theory, if the cells contain 12 per cent. of juice, transfusion will go on till an equal weight of water contains 6 per cent. of sugar, while by the passage of water into the cell the juice there is reduced to the same density. Taking the 6 per cent. watery solution and with it treating fresh roots containing again 12 per cent., a 9 per cent. solution will be attained, which on being brought a third time in contact with fresh roots would be raised to a density of 10·5. Thus theoretically seven-eighths of the whole sugar would be obtained at the third operation, and it is on this theory that the diffusion process is based. In working the process a range of